MI Note 0027A
150 GeV and Revised 120 GeV Ramps

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This note describes the 150 GeV ramp for the Main Injector, and revised calculations of the 120 GeV ramp. The change in the 120 GeV ramp is a reduction of the estimate of the ring resistance from 400 mΩ to 320 mΩ. The ramp and rf waveforms have not changed. There are a number of considerations which make the 150 GeV ramp different from the 120 GeV ramp at high field. The low field properties, i.e. ramp rate and rf voltages, are the same as the 120 GeV ramp, except for 8 GeV dwell time. The ramp given below is appropriate for fixed target injection into the Tevatron; the collider injection ramp will need a longer flattop, and will have to be restricted in its repetition rate. The ramp shown is intended to be run twice in succession, once a minute, with 120 GeV cycles the remainder of the time. The transformers for the Main Injector are being sized for a current (average between peak and rms) of 6500 A; if this ramp is to be run repetitively, the repetition rate must be slowed to reduce the rms current to ~3600 A (~5.4 sec rep rate). The 120 GeV slow spill ramp is also given.

There are 150 GeV files on Page M3, under **$2D** resets. The 120 GeV files have been moved to the $2D resets also. There are also 150 GeV files on D126. Copies of the waveforms are attached. Please inform me if you discover problems with any of these waveforms, so that I can correct them and issue an update. The 120 GeV slow spill flattop allows for 1 second of slow spill. Any time required for rf manipulations for producing a satisfactory beam distribution will reduce the available spill time. Mixed mode of antiproton production plus slow spill will require an additional .1-.2 sec. (See MI Note 40 for comments regarding extraction at F17.) The observent reader will note that there is in fact an extra 15 Hz increment at the end of the ramp. Elimination of this increment would reduce the cycle time to 2.80 sec, while increasing the power and rms currents.

<u>150 GeV Ramp description</u>

The input to the calculations of power supply voltage are: 9417 A = 150 GeV/c; L = 613 mH; R = 320 mΩ. While this is the "proper" value for 150 GeV, saturation is not taken into account. Approximately 12000 V is the maximum available during convert, slightly less during invert. The resistance is comprised of 254 mΩ from the magnets, with the remainder coming from bus work, filters, etc. There is still some uncertainty in this number, and an extra 11 mΩ has been added to err on the conservative side.

The ramp begins with a .441 sec injection level, (.108 sec, as for the 120 GeV, single batch ramp, plus .333 seconds for five additional batches). Feeder current limitations force the ramp rate to fall off above 120 GeV. The result of this restriction is that as one approaches the parabola coming into flattop, no more than nine power supplies can be turned on. Ramp regulation which puts supplies into bypass is required. **While this improves the feeder currents, it raises the peak voltage to ground and bus to bus voltage that the magnets experience.**

Invert has been adjusted in a similar manner. Flattop is 250 msec long, which should be adequate for phase locking to the Tevatron and cogging by a maximum of 10 buckets, the difference in revolution times being used to provide the remainder of the cogging. The undershoot and subsequent dwell time are the same as the 120 GeV ramp. The total time is 2.4 sec, or 36 15-Hz cycles.

Rf Voltage

The rf voltage curve is roughly the same as for the 120 GeV ramp. At high field, the rf voltage is limited to 534 kV to match the 1.2 MV in the Tevatron; for Collider operation, these levels are reduced to 356 kV and 800 kV, respectively.

Power Supply Control

The power supplies are assumed to be controlled differently on different cycles. For the fast cycling 120 GeV cycle (with very short flattop) one power supply is used at 8 GeV, but as the ramp begins, the remaining power supplies are turned on simultaneously. For the 150 GeV cycle, the supplies are turned on and off as required by voltage demands, with either 1, 4, 8, 10 or 12 supplies on at once. For the 120 GeV slow spill cycle, 1, 3 or 12 supplies are energized. This sequential turn-on is required to minimize voltage to ground distributions and rms feeder currents.

The attached pages detail the ramp waveform, rf waveform, beam properties and power calculations. The table below summarizes some of the relevant properties and power requirements for each of the ramps.

Ramp	150 GeV	120 GeV (Fast)	120 GeV (Slow Spill)	
DIPOLE BUS				
Cycle Time	2.4	1.4667	2.8667	sec
Max. Current	9417	7100	7100	A
RMS Current	5434	3765	4988	A
Power	9.4	4.5	8.0	MW
RMS Feeder Current	1991	2054	1473	A
Peak Feeder Volt-Amps	98	94	94	MVA
Average Feeder Volt-Amps	48	49	35	MVA
QUAD BUS (sum of both)				
Max. Current	3630	2904	2904	A
RMS Current	2095	1540	2040	A
Power	4.8	2.5	4.4	MW
RMS Feeder Current	444	316	336	A
Peak Feeder Volt-Amps	21	16	16	MVA
Avearage Feeder Volt-Amps	11	8	8	MVA